South African Reserve Bank
Working Paper Series
WP/18/02

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Authorised for distribution by Chris Loewald

June 2018

South African Reserve Bank

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Short-lived supply shocks to potential growth

Byron Botha [*] Franz Ruch[†] Rudi Steinbach [‡]

June 21, 2018

Potential growth, or the non-inflationary rate of growth in output, is generally viewed as a slow-moving and smooth process. This implies that all the quarter-to-quarter volatility in real gross domestic product (GDP), regardless of origin, is reflected in the output gap. Some of this volatility can, however, be attributed to short-lived supply shocks. Recent examples include the platinum-sector strike of 2014 and the drought of 2015/16 that are more accurately identified as temporary shifts in potential growth. We update the South African Reserve Bank's current finance-neutral estimates of potential growth to account for these short-lived supply shocks. In addition, the model-generated supply shocks that are believed to shift potential growth rather than the output gap are compared to similar shocks from a structural vector autoregression (SVAR) model. It is argued that the resulting output gap more accurately reflects a measure of demand pressures in the economy at any given point in time.

JEL Classification: O40; C11 Keywords: Potential growth; Bayesian estimation

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Summary

The output gap is used to indicate whether demand in an economy is excessive or deficient relative to the available resources used in production. When demand is excessive, upward pressure on inflation generally ensues. Conversely, when demand is lacking, disinflationary pressure results.

The output gap is measured by comparing the *realised* output of an economy to its potential level of output. There are generally two main approaches to estimating potential growth. Structural models posit a production function for the economy that transforms technology, labour, and capital into potential output. Alternatively, there are statistical filtering methods which assume that structural growth is the portion of observed growth that persists over relatively long periods of time, often referred to as the 'trend'.

We use a semi-structural multivariate filter to identify a smooth long-run potential growth rate. However, temporary supply shocks also affect potential growth. Their impact on potential needs to be accounted for to obtain a more accurate assessment of the output gap in periods when these transitory shocks hit. A drought, for example, depresses production for a season or more, after which output rebounds to its pre-drought level. Typically, such a depression of output does not persist long enough to be picked up by statistical measures of potential growth. As a result, these short-term decreases in production are reflected in a wider output gap. While this implies less demand and points to lower inflation, the immediate effect of the drought is to put upward pressure on inflation, specifically from rising food prices.

In order to place supply-side variations in output within the potential output and not within the output gap, we need to correctly identify supply shocks. The augmented model identifies supply shocks by determining which changes in output are not demand-related. It does this by isolating the demand components described by the Phillips curve and defining an additional supply shock that can only affect potential output. The resulting measure of potential growth still shows a persistent decline following the global financial crisis. But it now also includes variations related to temporary changes in supply, that capture, for example, the effects of the protracted strikes in the platinum-mining sector and of the 2015/16 drought.[1]

How has the output gap changed as a result of the new approach? Using the drought as an example, the declines in observed GDP related to the drought now serve to lower potential output over that period. To the extent that the drought-induced fall in GDP is included in potential growth, it is removed from the output gap. As a result, the output gap is less negative during the drought than in the old approach. Our new estimates reveal that the South African economy has been subjected to a barrage of negative supply shocks following the global financial crisis, the result of which is that, in the new approach, the output gap is less negative *on average* over the entire period than in the old approach.[2]

[1] The supply shocks that originate from this modification are corroborated by their close correlation to short-run supply shocks that are identified in a structural vector autoregression (SVAR) model.

[2] The output gap is more negative during the period from 2013 to 2015 in the new approach.

Contents

List of Tables

List of Figures

1 Introduction

Potential growth, or the non-inflationary rate of growth in output, is generally viewed as a slow-moving and smooth process. This implies that all the volatility in real gross domestic product (GDP), regardless of origin, is reflected in the output gap. However, the smooth nature of potential growth turns out to be problematic in practise, as the South African economy is regularly hit by transitory supply shocks, that should arguably affect the economy's productive potential rather than the output gap. Here, specific episodes of turmoil in the mining sector and, more recently, one of the worst droughts on record are fitting examples that we will revisit. Transitory supply shocks aside, gross domestic product (GDP) has also seen a secular decline in trend growth over the last decade. This paper extends our model estimates of potential growth to incorporate both these features.

We update the South African Reserve Bank's current, finance-neutral, estimates of potential growth to account for these short-lived supply shocks. Using a structural vector autoregression (SVAR) model, we identify supply shocks that should shift potential growth rather than the output gap, and compare them to their counterparts from the updated model's estimates. With our potential output estimate capturing temporary supply shocks as they arise, the resulting output gap estimate is more reflective of demand pressures in the economy at any given point in time.

This paper starts by reviewing some of the techniques used to measure potential growth, followed by a short survey of the methods that have been used in the South African Reserve Bank (SARB). Thereafter, details on the empirics of the supply-side extension to the current finance-neutral method are given. Finally, the new method is used to decompose both potential growth and inflation to show the explanatory power of the identified short-term supply shocks.

2 Literature review

Empirical studies on potential growth in South African date back to De Jager and Smal (1984). However, the literature blossomed in the post-Apartheid era, when authors such as Burrows and Smit (1999) and Arora and Bhundia (2003) focused on measuring the country's improving potential growth prospects. More recently, South Africa's deteriorating growth prospects in the aftermath of the global financial crisis has fuelled some renewed interest in the topic, as researchers try to understand both the extent and the underlying drivers of this persistent downturn. A non-exhaustive list of these studies includes Klein (2011); Ehlers, Mboji, and Smal (2013); Anvari, Ehlers, and Steinbach (2014); Kemp (2015; 2016); and Fedderke and Mengisteab (2017). This section looks at some of the approaches adopted in the South African literature and the narrative developed around potential growth.

2.1 Approaches to estimating potential growth

Statistical, structural, and semi-structural approaches have all been implemented in the South African literature. Statistical approaches include univariate filters, such as the Hodrick-Prescott (HP) and Christian-Fitzgerald (FC) filters, or modifications thereof, implemented in, among others, Arora and Bhundia (2003) and Fedderke and Mengisteab (2017). Multivariate filters, including those used by Anvari, Ehlers, and Steinbach (2014) and Kemp (2015), use additional economic information and relationships to better define potential growth. Anvari, Ehlers, and Steinbach (2014) and Kemp (2016) provide evidence that a multivariate filter can significantly reduce the error made in real-time estimates.

Structural approaches to estimating potential growth include:

- production function models (implemented in, among others, Burrows and Smit, 1999; Ehlers, Mboji, and Smal, 2013; and Anvari, Ehlers, and Steinbach, 2014);
- structural vector autoregressive (SVAR) models; and
- general equilibrium models, both from first principles and in reduced-form gap models.

In production function models, potential real GDP growth is disaggregated into the factors of production: labour, capital, and total factor productivity. Structural VAR models use identification restrictions such as in Blanchard and Quah (1989) to identify long-run supply shocks and hence potential growth. General equilibrium models generally use New-Keynesian models with a Phillips and an investment-savings (IS) curve to identify the output gap and potential growth.

Semi-structural approaches are a mixture of statistical and structural approaches using the advantages of each. These include the finance-neutral potential growth estimates in Anvari, Ehlers, and Steinbach (2014), and Kemp (2015).

2.2 South Africa's potential growth

South Africa's potential growth has slowed significantly after reaching a peak in the mid-2000s. Anvari, Ehlers, and Steinbach (2014) estimate that the country's potential growth declined from around 4% at its peak in the mid-2000s to around 2% after the global financial crisis. Kemp's (2016) estimates corroborate this finding and ascribe the slowdown to declining total factor productivity growth.

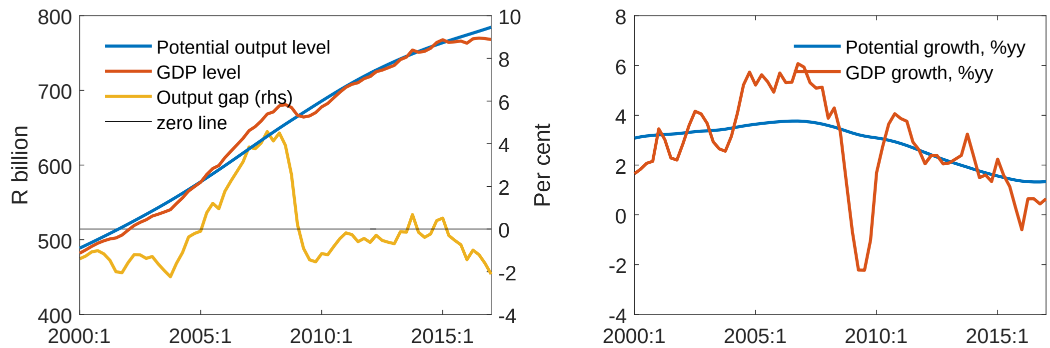
Fedderke and Mengisteab (2017) provide sectoral results with large sectoral disparities. Potential growth in construction as well as in the finance, insurance, real estate and business services sector are estimated to be significantly more robust than in mining and manufacturing.

A consistent finding in the potential growth literature, highlighted in all papers that provide some form of comparison – see, for example, Anvari, Ehlers, and Steinbach (2014) and Fedderke and Mengisteab (2017) – is that the potential growth estimates differ depending on the method applied. This suggests that judgment is required when considering potential growth estimates. Some of these discrepancies, however, are related to common problems in the methodologies, such as the endpoint problem in statistical filters and data revisions to GDP.

The SARB follows the approach of other central banks and international agencies by having a suite of models to estimate potential growth. These include simple statistical filters, semi-structural multivariate filter models, a production function model, and a SVAR model. The finance-neutral estimate in Anvari, Ehlers, and Steinbach (2014) has to date been used as its official measure of potential growth for forecasting.

The official estimate of potential output shares the view with a number of other recent studies that the evolution of potential output, i.e. potential growth, is a fairly smooth process (see, for instance, the International Monetary Fund, 2014; Kemp, 2015; and Fedderke and Mengisteab, 2017). Figure 1 illustrates the smooth nature of potential growth, and the output gap that it implies.

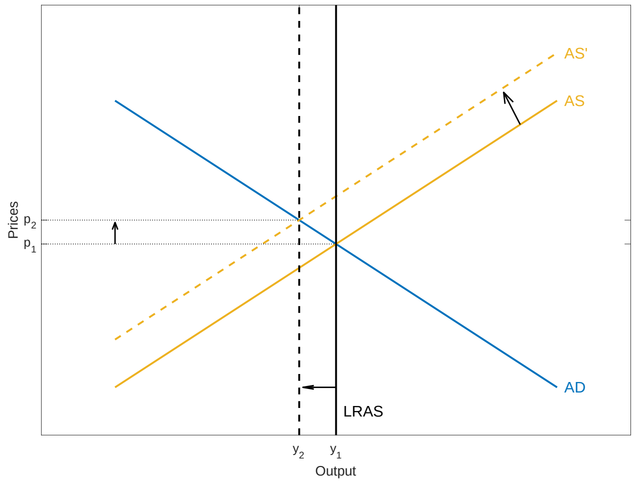
Figure 1: Potential growth, evolving smoothly



3 Adapting the SARB's approach to potential growth

A smooth and slow potential growth implies that all the volatility in actual GDP, regardless of its origin, will be reflected in the output gap. Recent examples where the output gap would have widened due to such abrupt changes in GDP are the platinum-sector strike of 2014 and the 2015/16 drought. Shocks like these, however, temporarily shift the aggregate supply curve (i.e. potential output) to the left (see Figure 2), rather than move demand.

Figure 2: Back to basics: Aggregate Supply-Aggregate Demand (AS-AD)



With current methods, the fall in production is reflected *incorrectly* as a more negative output gap. As shown in Figure 2, a shift in demand has the opposite impact on inflation to a shift in supply. Lower demand reduces inflation while lower supply puts upward pressure on prices (p1 to p2).

Similarly, the severe drought of the summer of 2015/16 has limited the capacity of the agricultural sector to deliver its normal produce. This event has temporarily shifted aggregate supply of the South African economy to the left, and in doing so, has placed upward pressure on prices. However, the current methodologies in which potential growth is a smooth process would ascribe this slowdown to a further widening of an already negative output gap, incorrectly implying less demand and lower prices.

Our new method allows shorter-run supply shocks to affect potential growth temporarily. As a result, the output gap obtained from the new methodology should more accurately measure demand pressures in the economy.

4 The model

The approach we introduce dates back to earlier studies, such as Clark (1987), where the cyclical component of economic activity in the United States is estimated within a highly parsimonious model consisting of a minimal number of equations. More recently, Laxton et al. (2015), Alichi (2015) and Alichi et al. (2017) include this specification in larger models that also account for other structural factors such as inflation and unemployment. The core structure of the methodology is outlined below.

Let $\bar{y}_t$ be the (log) level of potential output, while g_t is the *smooth* quarter-on-quarter annualised underlying trend growth rate of the economy.[3]

In the SARB's current methodology, there is no distinction between the growth rate of the non-inflationary level of potential output, $\Delta\bar{y}_t$, and that of underlying trend growth, g_t. From one quarter to the next, it simply evolves according to the underlying potential growth rate:

$$\Delta\bar{y}_t = g_t/4 \tag{1}$$

where $\Delta\bar{y}_t = \bar{y}_t - \bar{y}_{t-1}$.[4]

In the new methodology, where transitory supply-side shocks such as droughts and strikes may cause the growth rate of potential output to deviate temporarily from the smooth underlying growth process, an additional source of variability is required. This is achieved by allowing the quarter-on-quarter changes in the level of potential output ($\Delta\bar{y}_t$) to deviate from the underlying potential growth rate (g_t) through the inclusion of the residual term $e_t^{\bar{y}}$. Equation 1 then becomes:

$$\Delta\bar{y}_t \quad = \quad g_t/4 + e^{\bar{y}} \tag{2}$$

where $e_t^{\bar{y}}$ acts as a shock to the level of potential output.[5] This shock conveniently averages zero over time, thereby allowing potential output to evolve around the underlying trend growth rate. Hereafter, an equation is needed that describes the evolution of the underlying potential growth process, g_t:

$$g_t \quad = \quad \rho_g g_{t-1} + (1-\rho_g) g^{ss} + e_t^g, \quad \rho_g < 1 \tag{3}$$

Equation 3 expresses g_t as a function of its history, the economy's long-run steady state growth rate g^{ss}, and a residual term e_t^g. Shocks to the underlying trend growth rate are captured by the residual e_t^g, and lead to persistent deviations of underlying trend growth from its long-run steady state growth rate g^{ss}. In the absence of such shocks, the underlying trend growth rate eventually converges to its long run steady state growth rate.

Together, these equations allow for a potential output growth process with three distinct features:

[3] Note that $\bar{y}_t = \log(\overline{Y}_t) * 100$, where $\bar{Y}_t$ is the level of real GDP. This log transformation of the level of GDP conveniently simplifies the model specification, as the first difference of $\log(\overline{Y}_t) * 100$, i.e. $\bar{y}_t - \bar{y}_{t-1}$, approximates quarter-on-quarter *percentage* change in non-annualised terms.

[4] Since g_t represents *annualised* potential growth, it is de-annualised by $g_t/4$ for Eq. 1 to hold.

[5] For practical purposes, this equation includes an additional parameter θ that governs the process through which g_t and $\Delta\bar{y}_t$ converge over the forecast horizon. It is excluded in text for ease of reference.

1. A constant long run potential growth rate equal to the steady state growth rate g^{ss}, representing long-run equilibrium.
2. Persistent deviations from this long-run equilibrium, brought about by shocks to the underlying trend growth rate g_t. The evolution of g_t over time is smooth and characterizes medium-term equilibrium dynamics.
3. Short-lived deviations of potential growth from these medium-term dynamics are brought about by transitory shocks to the level of potential output as shown in Equation 2.

Subtracting the (log) level of potential output from real GDP yields the output gap:

$$\hat{y}_t = y_t - \bar{y}_t \tag{4}$$

where y_t is (log) real GDP and $\hat{y}_t$ is the output gap. The output gap is specified as being finance neutral, similar to Anvari, Ehlers, and Steinbach (2014):

$$\hat{y}_t = \beta^{\hat{y}} \hat{y}_{t-1} + \gamma^c c_t + e_t^{\hat{y}} \tag{5}$$

where c_t is log demeaned credit extension that evolves as an AR(1), $c_t = \kappa c_{t-1} + e^c$.

Finally, we add an open-economy Phillips curve to the structure. Our ultimate goal is to estimate a combination of potential growth and the output gap that accurately correlates with demand pressures in the real economy. As such, exploiting the theoretical relationship between the output gap and inflation (*i.e.* the idea that excessive demand is associated with elevated inflation, while lower inflation should correspond to periods of deficient demand) assists the estimation procedure when disentangling GDP growth into the part of it that is potential, and that which is related to excessive or deficient demand. The Phillips curve is specified as follows:

$$\pi_t^{core} = \alpha^{\pi} \pi_{t-1}^{core} + (1 - \alpha^{\pi}) E_t \pi_{t+1} + \alpha^{\hat{y}} \hat{y}_t + \alpha^q \hat{q} + e_t^{\pi} \tag{6}$$

where inflation π_t^{core} is defined as the quarterly log difference of core inflation. It is linked to past outcomes, the future expectations of inflation (as proxied by the two-year-ahead Bureau for Economic Research (BER) inflation expectations), the output gap $\hat{y}_t$, and the real exchange rate's deviation from its equilibrium level $\hat{q}_t$. [6,7]

[6] To indicate inflationary pressures, or the lack thereof, inflation in Equation 6 is expressed as a deviation from its average since 2000Q1.

[7] The real exchange rate is modeled as an AR(1) process: $\hat{q}_t = \tau \hat{q}_{t-1} + e^{\hat{q}}$.

5 Data

The data used in the estimation of the model are described in Table 1. Since private-sector credit extension is used in the output gap equation, it is demeaned in order to ensure that its mean is also zero. The real exchange rate gap is the deviation of the real exchange rate on a trade-weighted basis away from its equilibrium, as defined in De Jager (2012). Core inflation and inflation expectations are also demeaned using their mean from 2000Q1 to 2017Q1, and seasonally adjusted.

Table 1: Data

Variable		**Transformation (log)**	**Source**
y_t	Real GDP	level	Stats SA
c_t	Private-sector credit extension	1st difference, demeaned	SARB
π_t^{core}	Targeted inflation, excl. food and energy	1st difference, demeaned	Stats SA
$E_t\pi_{t+1}$	2-year ahead inflation expectations	1st difference, demeaned	BER
$\hat{q}_t$	Real exchange rate gap	deviation from equilibrium	De Jager (2012)

6 Estimation

We use Bayesian techniques to estimate most of the coefficients of the system and the unobserved variables, including potential growth ($\bar{y}$) and g. Table 2 indicates the priors used based in part on Anvari, Ehlers, and Steinbach (2014), as well as the maximised posterior values.

Table 2: Priors and posteriors

Coefficient	**Prior distribution**	**Mean**	**Standard deviation**	**Maximised posterior**
$\beta^{\hat{y}}$	Beta	0.88	0.05	0.919
γ^{c}	Gamma	0.3	0.1	0.102
α^{π}	Beta	0.5	0.2	0.182
$\alpha^{\hat{y}}$	Gamma	0.2	0.1	0.118
$\alpha^{\hat{q}}$	Gamma	0.05	0.02	0.049
τ	Beta	0.85	0.05	0.857
κ	Beta	0.34	0.2	0.337
θ	Gamma	0.3	0.1	0.164
$e^{\hat{y}}$	Inverse gamma	0.961	0.3	0.542
$e^{\bar{y}}$	Inverse gamma	0.961	0.3	0.471
e^{c}	Inverse gamma	2.0	0.5	2.356
e^{π}	Inverse gamma	0.6	0.5	2.121
$e^{E\pi_{t+1}}$	Inverse gamma	1.17	0.5	1.431
$e^{\hat{q}}$	Inverse gamma	5.3	1.5	5.244

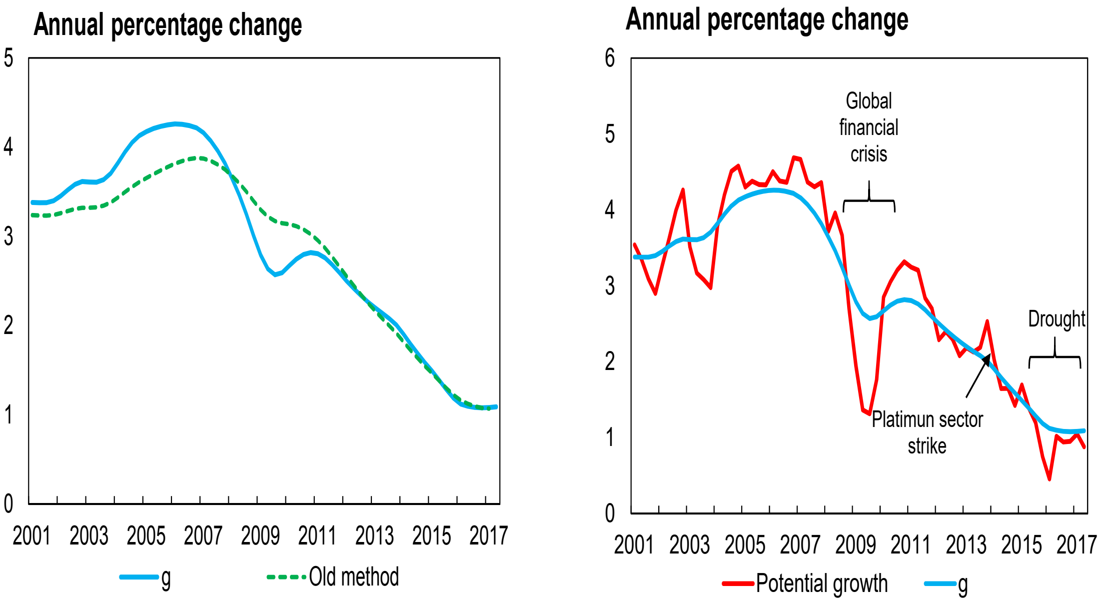
7 A comparison between the old and the new approach

Anvari, Ehlers, and Steinbach (2014) present an estimate of the smooth and slow moving process, g_t, which is currently used as the SARB's estimate of potential growth. Based on international best practice, they use credit extension to assist in identifying an output gap that is deemed to be finance neutral. While the new approach preserves this existing method to estimate potential and the output gap, it augments it in two ways: (i) adding short-lived shocks to potential growth; and (ii) adding inflation dynamics to assist in identifying the output gap (and hence potential).

The new approach to estimating potential growth has important advantages in terms of how we interpret the various shocks that are affecting the economy. Potential growth, the red line in figure 3b , is now much more responsive to the current developments affecting supply in the economy. Figure 3b highlights specific macroeconomic events that likely impacted on the movements in potential growth during the last decade. First, the global financial crisis led to a significant slowdown in potential growth. Thereafter, it rebounded briefly to levels closer to its pre-crisis norm, but this was short-lived (see Table 3). Since 2012, the domestic economy has been hit by a myriad of growth shocks that have fundamentally altered potential growth. These include adjustments in the mining sector to terms-of-trade losses, the six-month platinum-sector strike at the beginning of 2014, and the severe drought of 2015/16.

Figure 3: Potential growth: old vs new methodology

(a) Underlying trend growth **(b) g and potential growth**



The underlying trend growth does not differ substantially from the previous estimate in Anvari, Ehlers, and Steinbach (2014), as seen in figure 3a. The story behind the underlying trend growth remains unchanged: underlying trend growth accelerated through the early 2000s, reaching rates close to 4% in the mid-2000s, but it has since been on a downward trajectory, reaching lows of 1.1% by early 2017. Around this underlying trend are movements in actual, non-inflationary potential growth, which ultimately determines the output gap.

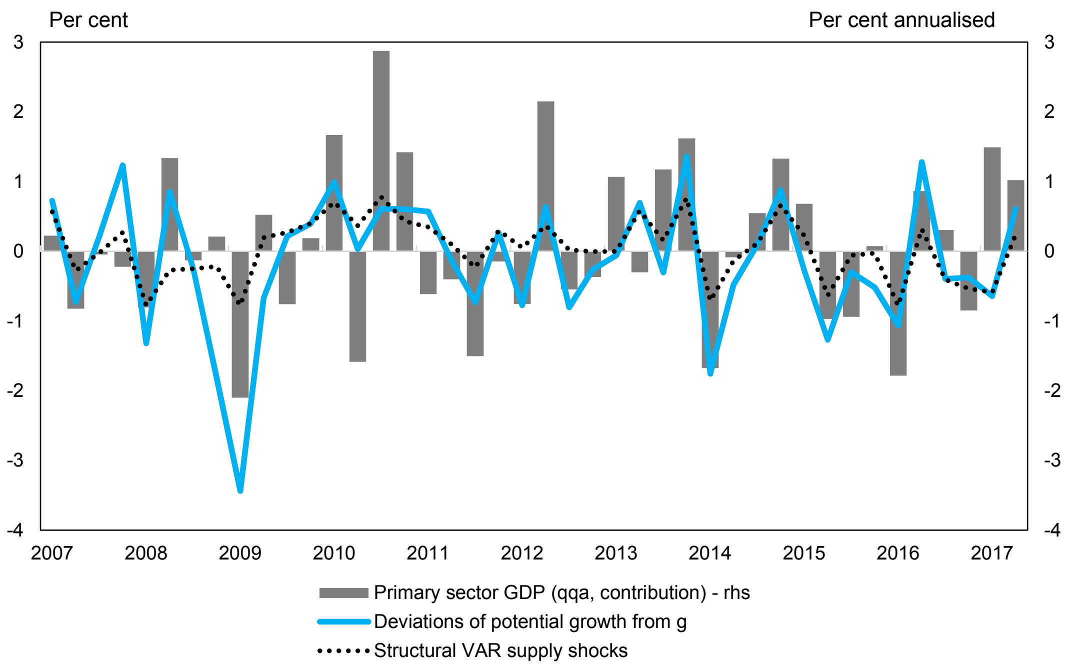
Table 3: Annual growth rates of g and potential growth

Annual growth rates	2008	2009	2010	2011	2012	2013	2014	2015	2016
Trend growth, g_t	3.0	2.5	2.8	2.6	2.3	2.0	1.6	1.2	1.1
Potential growth, $\Delta\bar{y}_t$	3.5	1.6	3.1	3.0	2.3	2.3	1.7	1.3	0.8

7.1 Supply shocks from a VAR: a confirmation

To confirm that the transitory supply shocks from our model are correctly identified, we estimate a basic SVAR model using a very similar identification scheme to that proposed by Blanchard and Quah (1989) in their seminal paper titled *The dynamic effects of aggregate demand and supply disturbances*. The result is shown in Figure 4. Transitory supply shocks that are estimated using our new method generally correspond to the supply shocks identified by the SVAR with a correlation coefficient of over 0.6. In addition, the estimated shocks from both models agree with the movements in primary-sector GDP, which is often the source of these supply shocks. Importantly, all three series are in agreement during the global financial crisis, the platinum strikes, and the drought.

Figure 4: Identifying supply shocks



7.2 The new output gap

The benefit of this new approach is that temporary supply-side events – i.e. those which shift the supply curve – are not reflected in the output gap as shocks to demand. The recent drought serves as an example. In the SARB's current output gap measure, most of the adverse effect of the drought on GDP ends up widening the output gap. This is the consequence when potential growth is a smooth and slowly evolving process. In reality, however, a drought would most likely decrease potential growth, as it is first and foremost a supply shock that raises prices and leads to a leftward shift in the supply curve. Over time, as a larger part of consumers' income ultimately flows to the purchases of more expensive food products, their demand for other goods and services declines. This second-round impact, where a drought leads to an eventual fall in demand, may contribute to a widening of the output gap. Nevertheless, the dominating impact should be the initial fall in supply. This distinction between demand and supply is vital, as the two outcomes have completely opposite effects on prices. If we assume the drought is purely demand-related, then this should lower prices, but if it is supply-related, then it should increase prices (see Figure 2).

Figure 5: Output gap: old vs new methodology

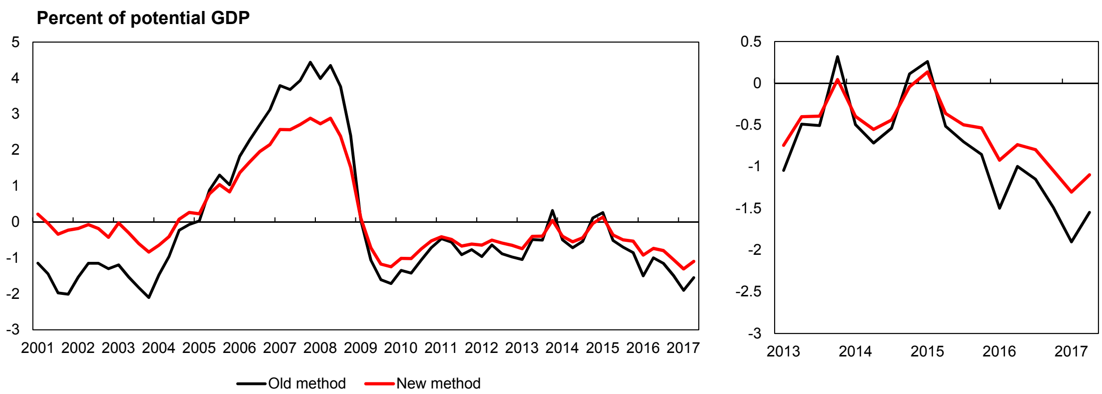


Figure 5 highlights the impact on the output gap from the new estimate of potential growth. The estimated output gap now suggests that the gap was narrower during the pre-crisis period. Following the crisis, the output gap is less negative during 2010 to 2014, as a consequence of the rebound in potential growth. Importantly, the gap is almost 0.5 per cent less negative by mid-2017 when compared to the previous method, as part of the drought-induced moderation in GDP is now accounted for by a temporary slowdown in potential growth.

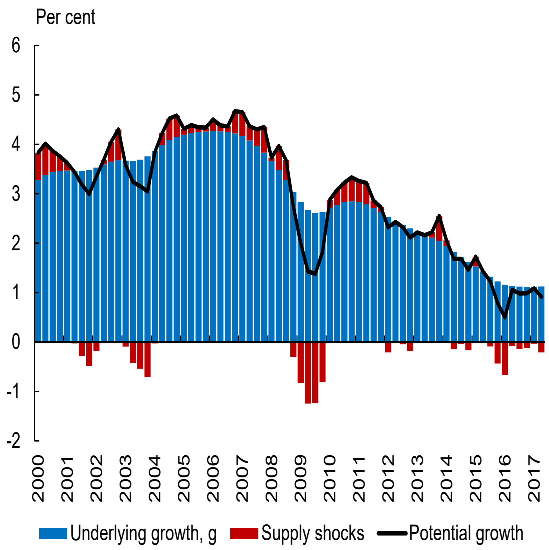
8 Model decompositions

The estimated model provides details on the behaviour of the variables of interest based on its underlying drivers. Figure 6 plots the decomposition of potential growth on an annual basis and of demeaned core inflation. These decompositions can be used to judge the overall ability of the model to explain growth and inflation dynamics.

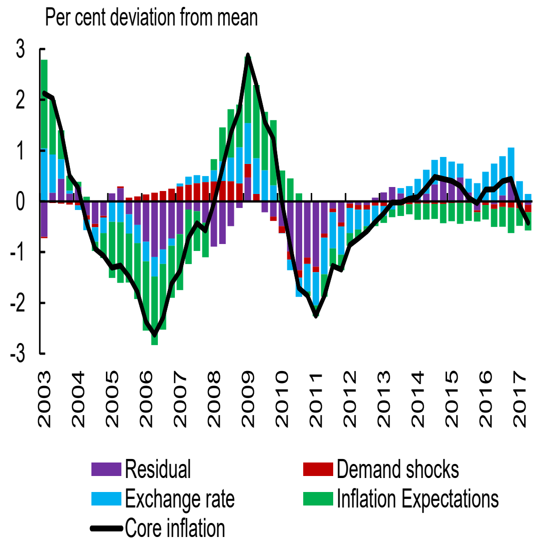
The non-accelerating inflation rate of potential output is a function of underlying potential growth and supply shocks (represented here on an annual basis). Underlying potential growth creates the anchor around which growth in potential output moves. Short-lived supply shocks play a supporting role in explaining potential growth movements, and become more important at specific points in history. For example, the adverse supply shocks that have affected the South African economy from mid-2015 have lowered potential growth by 0.2 percentage points on average.

Figure 6: Model decompositions

(a) Decomposition of potential growth



(b) Decomposition of core inflation



Core inflation (Figure 6b) is driven by developments in inflation expectations (represented by two-year-ahead inflation expectations), demand shocks, exchange rate developments, and its error term (labelled residual). The exchange rate contributes to core inflation movements, as expected, raising inflation during episodes of significant exchange rate depreciation, including in 2003 (from the 2001-02 episode), in 2008-09, and 2014-2016. Demand shocks generally follow the shape of the output gap, contributing to inflationary pressures over much of the mid-2000s, but contributing to lowering inflation since the global financial crisis. Inflation expectations (measured as deviations from its mean) are backward-looking and persistent, contributing to lower core inflation when expectations are below its mean and raising core inflation when above.

9 Forecasting inflation

The ultimate test of our new output gap measure is its ability to forecast inflation. In this section we test whether the new measure produces better forecasts of core inflation inflation, compared with the old output gap measure. To achieve this we estimate two Bayesian VARs that consist of four key variables: targeted inflation excluding food and energy, the real interest rate gap, the real exchange rate gap, and the respective new and old output gap measures.[8][9] The BVARs are estimated from 2000Q1 to 2010Q1 with out-of-sample forecasts produced recursively over the remainder of the sample.[10] We generate forecasts of the annual change in core inflation from one- to eight-quarters-ahead. Table 4 shows the ratio of the root mean squared forecast errors (RMSFE) of the new output gap relative to the old measure. A value below one means that the new output gap measure produces more accurate forecasts. It is clear from the table that the new output gap significantly improves the forecasting performance of inflation. At one-quarter-ahead the new measure is 8 per cent better increasing to an outperformance of 37 per cent eight-quarters-ahead. On average the new output gap measure produces forecasts that are 22 per cent more accurate than the old measure.

Table 4: RMSFE of the new output gap relative to the old

Quarters ahead	$t+1$	$t+2$	$t+3$	$t+4$	$t+5$	$t+6$	$t+7$	$t+8$
Ratio	0.917	0.874	0.838	0.807	0.796	0.734	0.661	0.627

10 Conclusion

This paper introduces a new method for dealing with temporary supply-side events that shift potential growth but which cannot be adequately dealt with in the current methodological approach to potential growth. The extensions to the model allow the SARB to account for short-lived supply-side shocks, while more accurately identifying the impact of the output gap by leveraging inflation dynamics. As a result, this new method yields an output gap that more accurately represents the demand shifts that the South African Reserve Bank (SARB) would want to respond to. Moreover, the SARB's new approach does not undermine its current communication around issues of potential growth, as the smooth measure of potential growth used to date is nested in the augmented model.

[8] The Bayesian VARs have a lag length of four. A Litterman prior is used with the mean on the first lag set to zero, and a hyperparameter on the exponential increase in weight on the greater lag lengths set to 5.

[9] The variables used in the VAR are estimated in Botha et al. (2017).

[10] It is worth highlighting that we use only the full sample's estimate of potential growth as presented in this paper, and do not undertake a real-time exercise.

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Appendices

A List of abbreviations

AS-AD	Aggregate supply-aggregate demand
BER	Bureau for Economic Research
CF	Christiano-Fitzgerald filter
CPI	Consumer price index
G	*smooth* quarter-on-quarter annualised underlying trend growth rate
GDP	Gross domestic product
HP	Hodrick-Prescott filter
IS	Investment-Savings
LRAS	Long-run aggregate supply
MPC	Monetary policy committee
SARB	South African Reserve Bank
Stats SA	Statistics South Africa
SVAR	Structural vector-autoregression